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Narrator: Welcome to Space Place Musings, a Podcast in which an expert answers questions from our Space Place museum and astronomy club partners across the nation. I'm Diane Fisher, of the New Millennium Program. Our expert is Dr. Marc Rayman, a scientist at the Jet Propulsion Laboratory. Marc, our friends at the Back Bay Astronomy Club in Virginia Beach, Virginia, have a somewhat unusual question: What powers a comet?

Rayman: Well, that's an interesting way to look at comets. It does seem as if they must be under some kind of power like a rocket or a spacecraft with thrusters. Comets travel very fast, loop around the Sun, and have long tails.

Narrator: But what is a comet made of?

Rayman: A comet is a chunk of material left over from the formation of the solar system. About 4.6 billion years ago, our solar system formed from a vast cloud of gas and dust. More than 99% of the material in the cloud collected at the center and formed the Sun. Other big clumps of gas and dust became the planets, including Earth. Some of the material that didn't get caught up in the Sun or planets gathered into smaller chunks, sometimes just a few kilometers across. Many of these chunks are what we call comets.

Narrator: But don't comets have really odd, off-kilter orbits? Why would that be if they formed from the same cloud as the planets?

Rayman: Because the comets are much lighter and smaller than planets, they are easily pulled this way and that by the gravity of the planets (or, in some cases, even by stars). So when we see them streaking through the solar system, they often aren't following the kind of neat, nearly circular orbits that most planets do.

Narrator: So are comets made of ice, rock, gas or what?

Rayman: The solid part of the comet, its "nucleus," is like an icy dirtball with pockets of air trapped inside. When a comet's orbit brings it into the inner solar system, some of the ice and gas are heated by the Sun, and they expand to form a cloud around the nucleus. Although the nucleus may be only a few kilometers across, the cloud, called a coma, can be thousands of kilometers across—even larger than Earth.

Narrator: That explains why we can see them even though the nucleus is quite small. But what causes the long tail?

Rayman: Light and other radiation from the Sun push on the gas and dust in the coma, blowing the material away to form a tail that can be millions of kilometers long. So the tail always points away from the Sun, regardless of whether the comet is traveling toward the Sun or away.

Narrator: But what about our original question? What does power the comet?

Rayman: One answer to what powers a comet is simply that the Sun does. It provides the heat that drives some of the material from the nucleus into the huge coma, and it provides the pressure to push some of that into the long and beautiful tail.

Narrator: And what keeps the comet going around the Sun?

Rayman: Well, comets formed in the rotating cloud that produced the solar system, so that rotation got them started on their orbits of the Sun. This is the same reason Earth and the other planets orbit the Sun. But still another force acts on comets. When gases inside the nucleus expand under the heat of the Sun, they often shoot through holes or weak spots in the crust of the nucleus, like the steam coming from the hole in a tea pot. The expanding gas and dust escape in jets, having the same effect as thrusters on a spacecraft, changing the comet's path, and, by the way, making its orbit hard for astronomers to predict precisely.

Narrator: How do they do it? A couple of spacecraft have come very close to comets in the past few years.

Rayman: Quite true. I was lucky enough to be in charge of Deep Space 1 when it flew through the coma of Comet Borrelly in September 2001. The spacecraft had already accomplished its primary mission, so this was a bonus, risky maneuver. We had to design and upload some special software modifications for our advanced autonomous navigation system, which used the spacecraft's high-tech camera. We made the spacecraft on its own find the comet's nucleus deep within the coma and take pictures of it.

Narrator: And how did that go?

Rayman: The meeting with the comet went just perfectly, and that truly was one of the high points of my life. My mission logs from that month on the Deep Space 1 website tell the whole, hair-raising story. You can find the logs at nmp.jpl.nasa.gov/ds1.
Narrator: Yes, as I recall, your log entries read like a thrilling action adventure. Marc, thanks for answering our partner's question. And thanks to you out there for stopping by to hear more Space Place Musings.

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